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A FOUR SIDED SHIELD STRUCTURE FOR A PERPENDICULAR WRITE HEAD

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FIELD OF THE INVENTION

The invention relates to the general field of magnetic disk storage systems with particular reference to shielding perpendicular write heads.

BACKGROUND OF THE INVENTION

One of the key advantages of single-pole (SP) head/media, with a magnetically soft underlayer (SUL) and a perpendicular recording system, is the capability to provide a larger write field (than that of a ring head) to enable writing into the relatively thick media with high anisotropy constant. The latter quality leads one to assume better thermal stability associated with perpendicular recording.

FIG. 1 is a schematic representation of a typical single pole vertical recording system of the prior art. Seen there is single write pole 13 whose ABS (air bearing surface) moves parallel, and close to, the surface of recording medium 16. The latter comprises an upper, high coercivity, layer (not shown) on a magnetically soft underlayer. Coils 12

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generate magnetic flux in yoke 11 which passes through main pole 14 into tip 13 and then into media 16 (where a bit is written). The magnetic circuit is completed by flux that passes through the soft under layer and then back into return pole 11. The space enclosed by the yoke and poles is normally filled with insulating material 17.

The traditional single pole perpendicular writer with soft underlayer has two major problems --- insufficient field gradient in the down track direction and adjacent track erasure (ATE) caused by side fringing fields. The second problem becomes even more severe when the neck height of the single pole is reduced so as to increase the write field, i.e. overwrite (OW) capability.

A shielded pole perpendicular writer has been proposed to improve field gradient and to reduce ATE [1]. Unfortunately, the presence of shields also reduces the perpendicular field component so a shielded pole head will generate insufficient write field, even taking into consideration the increased in-plane field. Proper design of a shield pole head should take both ATE improvement and OW performance into consideration.

A routine search of the prior art was performed with the following references of interest being found:

A tapered pole is described in US 5,173,821 while Inamura describes a tapered

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pole portion at the tip in US 5,995,343. In US 5,600,519, Heim et al teach the use of a tapered pole tip to increase the head field and, in US 4,935,832, Das et al. show side shields around the write pole.

References:

[1] M. Mallary, A. Torabi, and M. Benakly "One terabit per square inch perpendicular recording conceptual design" IEEE Trans. Mag. 38 no. 4 1719-1724 Jul. 2002.

SUMMARY OF THE INVENTION

It has been an object of at least one embodiment of the present invention to provide a method to improve the magnetic field distribution of a single pole magnetic write head.

Another object of at least one embodiment of the present invention has been that said improved write head have minimum adjacent track erasure.

These objects have been achieved by shielding the main write pole on all four sides, with the regular return pole also serving as the leading edge shield. Additionally,

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the main pole is tapered. Tapering has also been used in conventional designs but, without the additional shields disclosed by the present invention, tapered shields suffer from excess adjacent track erasure. Optionally, the leading edge and side shields may be magnetically connected as well.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a typical single pole magnetic write head.

FIG. 2 is an ABS view of the four sided shielding structure of the invention.

FIG. 3 shows FIG. 1 modified to include the features of the invention.

FIGs. 4-6 compare contours of constant field magnitude for several configurations.

FIG. 7 shows the enhancement due to the leading-edge tapered pole head.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 2 where the principal elements of the invention can be seen from an ABS view as leading shield 15 (which is connected to the return pole as shown in FIG. 1), a trailing shield 21, and two side shields 22. The main pole 19 (see 13 in FIG. 1) is separated from shields by a different amount in each direction. Trailing shield 21, separated from main pole with a gap GT, effects the sharp magnetic field gradient needed for high linear density applications.

The side shield 22, separated from main pole 19 by a gap GS, prevent side-fringing magnetic fields from reaching the media and thereby reduce ATE. The leading shield 15, separated from the main pole by a gap GL, blocks field leakage from the leading side and also bridges the return pole and the trailing/side shields to keep the magnetic potential of the trailing/side shield grounded. Optionally, the side and leading shields may be magnetically connected to one other through connectors 23. Leading gap GL is usually larger than GT and GS, so that the field loss due to GL is negligible. Note that even though trailing and side shields are marked as different functional components in Fig 2, they may be fabricated simultaneously during device processing. To minimize the field loss, the thicknesses of the trailing shield and side shields are kept small (typically between about 0.05 and 0.4 microns).

FIG. 3 shows a side view of the head structure. In order to compensate for the loss of magnetic fields due to leakage to the shields, the main pole is tapered, preferably at the leading side to maintain high trailing field gradients. The combination of tapered main pole and leading shield increases the head field and minimizes magnetic field spread at the leading edge.

FIGs. 4 - 6 compare contours of constant field magnitude for a single pole head (FIG. 4), a single pole with trailing shield only (FIG. 5), and the shielded pole head of the present invention (FIG. 6). In all cases, the main pole had a 30 deg tapering angle. In the calculation, the following parameters were used: GT = 50nm, GS = 100 nm, GL = 300 nm. The spacing from head Air Bearing Surface (ABS) to soft underlayer was 50 nm. The thickness of trailing and side shield was about 0.1 microns while the thickness of the leading shield was about 0.3 microns. A large field gradient at the trailing edge that nevertheless confines the side-fringing field can be easily seen in the case of the structure of the present invention (FIG. 6). Without the side shields, the tapered pole heads would have produced side-fringing magnetic fields that were too large, thus causing excessive ATE.

FIG. 7 illustrates the calculated magnetic field enhancement due to the leading-edge tapered pole head. At a tapering angle of 30 degrees (curve 72), the write field is increased by more than 1500 Oe compared to a pole having zero taper (curve 71). The

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corresponding shielded tapered head produces as much magnetic field as does a single pole head with only a trailing shield but without any taper. In the latter case, the taper could not be used in any case because of excessive ATE. In short, the proposed shielded tapered-pole head achieves an optimal design in the trade-off between maximum write fields and minimum fringing fields at the price of a slight increase in head processing complexity.

What is claimed is: